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DRAFT TRANSLATION

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RADAR METHOD OF DETERMINING THE COEFFICIENT OF ELECTRON AFFIXION TO NEUTRAL MOLECULES IN THE METEOR ZONE REGION

code-2d

(Radiolokatsionnyy metod opredeleniya koeffitsienta prisoyedineniya elektronov k neytral'nym molekulyam v oblasti meteornoy zony)

Geomagnetizm i Aeronomiya
Tom I, No. 2, pp. 209-212,
Izad-vo A. N. SSSR, 1961.

ABSTRACT

Expounded is a method of determining the coefficient of electron affixion to neutral molecules in the region of the meteor zone that is based upon the utilization of meteor radioechoes' distribution by duration.

It is found from the experiment that the coefficient of affixion in the region of the meteor zone is approximately equal to $4 \cdot 10^{-15} cm^3 \, sec^{-1}$.

COVER TO COVER TRANSLATION

Daves, Greenhow and Hall [1] proposed a method of determining the coefficient of electron affixion to neutral molecules, that can be applied at simultaneous photographic and radar observations of separate bright meteors. Although of unquestionably great interest, this method is beset with complex observations and labor-consuming processing of their results. It is thus appropriate to apply another, simpler method only based upon the organization of radar observations of meteors. The distribution by duration of meteor radioechoes may be utilized to that effect.

BASIC CORRELATIONS. If the meteor trail disintegration is only the result of ambipolar diffusion, the variation of the volume density on the trail's axis is subject to the law [2]:

$$n_e = \frac{\alpha}{4\pi Dt} \qquad (1)$$

where α is the linear electron density in the trail; D is the ambipolar diffusion coefficient; t is the time having elapsed since the formation of the trail.

Let us note that during the obtention of formula (1) the finiteness of the ionized trail's initial radius was not taken into account. Therefore formula (1) may be utilized at not too small t values.

If during the first stage of trail's disintegration there mainly takes place its expansion under the effect of concentrated diffusion, in the subsequent places a vortex diffusion begins to take effect, and also processes leading to the decrease in the linear electron density in the trail: the recombination of electrons and ions, the electron affixion to neutral molecules etc. In case of long-lived trails (with durations of several minutes and longer), the basic process determining the variation of volume electron density is the affixion [1, 3, 4].

Neglecting the recombination and the turbulent diffusion, we find that the volume density of electrons on the trail's axis is [1]

$$n_e = \frac{\alpha}{4\pi D t}\, e^{-\beta_{\text{п}} n_{M} t}\,, \qquad (2)$$

where β_{π} is the coefficient of electron affixion to molecules; n_m is the volume density of molecules forming negative ions.

The time τ during which the volume density in the trail will decrease to a certain value n_{e1}, will be found from the transcendent equation (2). But if the trail had widened only under the effect of concentration diffusion, the volume density would have become equal to n_{e1} during the time τ_D after the formation of the trail, as this may be seen from (1):

$$\tau_D = \frac{\alpha}{4\pi D n_{e1}}\,. \qquad (3)$$

As follows from (3) and (2),

$$\tau = \tau_D\, e^{-\beta_{\text{п}} n_{M} \tau}$$

If n_{e1} is understood as being the critical volume density of electrons, τ and τ_D correspond to durations of meteor radioechoes [1, 2].

Therefore, equation (4) establishes the link between the reflection duration τ, observed in real conditions, and the duration τ_D, which would have taken place in the case of trail widening under the effect of ambipolar diffusion only.

For the determination of the magnitude $\beta_{\pi} n_M$, one may utilize the combined radar and photographic observations of separate bright meteors:

the duration would be directly measured by radar, while the variation of brightness along the meteor trail could be used for the determination of τ_D, which would take place only at manifestation of diffusion.

As pointed out earlier, such method was realized in [1].

It is appropriate to evaluate the magnitude $\beta_\pi n_M$ according to the results of radar observation of meteors, utilizing for that purpose the distribution by durations of meteor radioechoes, method which is described in the following.

The simultaneous measurement of radioecho duration and of the angle of the received beam's place allow the plotting of meteor radioecho distibution bu durations for the given (narrow) altitude interval.

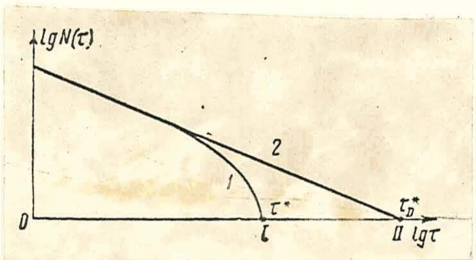

Fig. 1.

This distribution has the form pictured in Fig.1, wher for the sake of simplicity a logarithmic scale was adopted. Curve 1 corresponds to the distribution of durations τ, measured by radar.

The determination of duration τ_D, conditioned only by the ambipolar diffusion, may be made by a very simple method. It should suffice to take into account that in the region of small durations (of the order of a few seconds) the vortex diffusion, the affixion and the recombination influence the volume density of electrons to a lesser extent than the concentration diffusion. Thus, taking advantage of the law of radioecho distribution by durations, characteristic for small τ, and extrapolating it in the region of great durations, we shall obtain an idea of the pattern which would be observed at the presence of only the concentration diffusion. (straight line 2 of Fig.1).

As may be seen from Fig.1, the greatest observed radioecho duration τ^* corresponds to the point I.

Had the trail been disintegrating only as a consequence of diffusion, the radioecho duration determined by the point II, would be equal to τ^*_D.

Knowing τ^* and τ^*_D, we find $\beta_\pi n_M$ by a simple formula following from (4):

$$\beta_\pi n_M = \frac{2,38}{\tau^*} \lg \frac{\tau^*_D}{\tau^*} . \tag{5}$$

It is obvious that (5) gives the upper estimate of the magnitude $\beta_\pi n_M$ (since the turbulent diffusion and the rest was not taken into account).

Having plotted the distribution of radioecho durations for various intervals of heights, and determining for each of them the magnitude β_π, we may find the variation with altitude of the affixion coefficient. In this case, the altitudes at which portions of the trail are situated, and which reflect radiowaves, must be determined simultaneously with the variation of radioecho durations.

The described method is particularly simple if only the mean value of the affixion coefficient in the meteor region is required.

ESTIMATE OF THE MAGNITUDE OF THE AFFIXION COEFFICIENT CHARACTERISTIC OF THE METEOR ZONE REGION.

Let us take advantage of the distribution of meteor radioecho durations plotted according to the results of radar observations, conducted in Tomsk within the MGS Program.

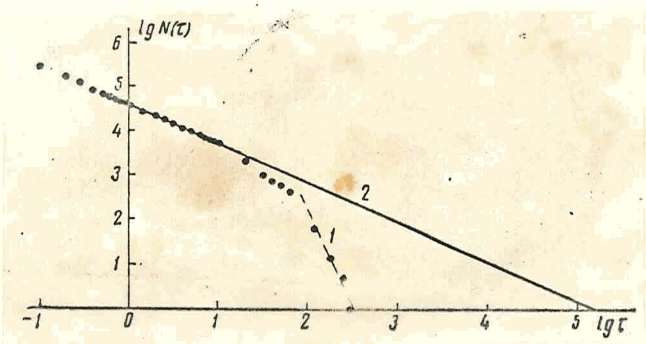

Fig. 2

The observations were conducted with the help of the long-range part of the station TPI-2 (wavelength $\lambda = 10$ m; power in the pulse $P_p \approx 100$ kW; repetition frequency $F_p = 600$ pulse/sec; pulse duration $\tau = 5$ microseconds. The antenna was a half-wave vibrator situated at the altitude $\approx \lambda/3$ over the ground and the signal registration was made with the aid of continually-extending photofilm. (see [5]).

336430 meteors were registered in the course of 1959, of which 43290 had durations $\geqslant$ 1 sec, and 388 — durations $\geqslant$ 1 min.

The integral distribution of meteor radioechoes by duration is plotted in Fig. 2 in the logarithmic scale. The results of experiments are indicated by dots.

Were the meteor trail's disintegration only due to ambipolar diffusion, the radioecho distribution by duration would be subjected to the law, approximately expressed by the line 2, not only in the τ-region of several seconds, but also in the region of greater durations through τ of the order of 10^5 seconds However, because of other processes among which the essential in the region of greater τ is the affixion, radioecho durations appear to be much lesser, not reaching in the given experiments even 10^3 seconds (line 1).

As may be seen from the graph, the greatest durations τ^* of the registered echoes give $\lg \tau^* = 2.5$, while the durations τ^*_D corresponding to them would have given at the presence of ambipolar diffusion only, $\lg \tau^* = 5.23$.

Substituting in (5) $\lg \tau^* = 2.5$, $\tau^* = 316$ and $\lg \tau^*_D = 5.23$, we shall obtain $\beta_\pi n_M \approx 0.02\ \text{sec}^{-1}$. This value obtained from the distribution of meteor durations, detected in the whole meteor zone, will obviously be characgeristic for an average altitude of about 95 — 96 km.

Let us note that the value $\beta_\pi n_M \approx 0.025\ \text{sec}^{-1}$ was obtained in reference [1] for h = 95 km.

Assuming that the oxygen concentration was equal to $n_M = 4.9 \cdot 10^{12}$ molecules/cm^3 as in [1], we find the magnitude of the affixion coefficient $\beta_\pi \approx 4 \cdot 10^{-15}$ cm^3 sec, which differs little from the result obtained in [1], which is: $\beta_\pi \approx 5 \cdot 10^{-15}$ cm^3/sec.

******* THE END *******

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